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NOISE MEASUREMENTS OBTAINED DURING VISUAL APPROACH MONITOR EVALUATION IN 747 AIRCRAFT

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By

Carole S. Tanner and Ray E. Glass

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EG&G
HYDROSPACE RESEARCH CORPORATION
San Diego, California

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for

AMES RESEARCH CENTER
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INTRODUCTION

This report presents the results of acoustic measurements made on the 747 aircraft during Visual Approach Monitor (VAM) evaluation approaches. The approaches were made using a Visual Approach Monitor manufactured by Sunstrand Data Control. This display is designed to improve approach and landing precision under visual flight rule conditions.

The purpose of the acoustic portion of the test was to measure, evaluate, and identify the noise levels during various types of aircraft approaches. Six noise measurement sites were positioned on the centerline of the approach ground track. The six noise measurement stations on the approach ground track were positioned between approximately 1 and 6 nautical miles from runway threshold. The 1-nautical mile point was chosen as the beginning of the ground track because it is specified as the approach measurement point in the FAA noise certification requirements. The 6-nautical mile point was chosen for its proximity to the point where the approach is initiated.

The flight tests were conducted on 10 March 1972 at the Stockton Metropolitan Airport.

APPARATUS AND METHODS

Aircraft and Test Profiles

The aircraft used for the tests was a Boeing 747 with four Pratt and Whitney JT9-3A turbofan engines. Nominal aircraft gross weight varied from 503,000 pounds to 398,000 pounds. This will result in an approximate variation of 1.5 EPNdB in the measured noise.

The aircraft flew five basic test profiles outlined in Figure 1. Profile 1 is the standard 2.5-degree ILS approach at Stockton. Profile 2 is a VAM low capture of the 3-degree approach. Profile 3 is a VAM 3-degree glide slope standard approach. Profile 4 is a VAM high capture approach with an initial 5-degree flight path angle. Profile 5 is a VAM high capture approach with an initial flight path angle of 6 degrees.

Acoustic Measurements

Acoustic data were acquired using six battery-operated portable acquisition systems. Figure 2 presents a block diagram of the systems. The typical system utilizes an analog tape recorder, microphone system, and a threshold detection circuit. The microphone system which runs continuously senses the existing noise level. When that level exceeds a preset voltage, the threshold circuit sets a relay which applies power to the tape recorder. The recorder is turned off after the noise level falls below the threshold. This method was feasible due to the limited air traffic at the Stockton Airport.

Field technicians checked system operation and tape supply and administered a single frequency tone calibration at one half-hour intervals. Further, each system was calibrated over a frequency range of 50 to 10,000 Hz using an electrical signal consisting of tones at the one-third octave center frequencies. Figure 3 is a typical frequency response.

The high frequency pre-emphasis is removed during processing but provides a better signal for analog recording since it compensates for high frequency sound attenuation due to the atmospheric absorption.

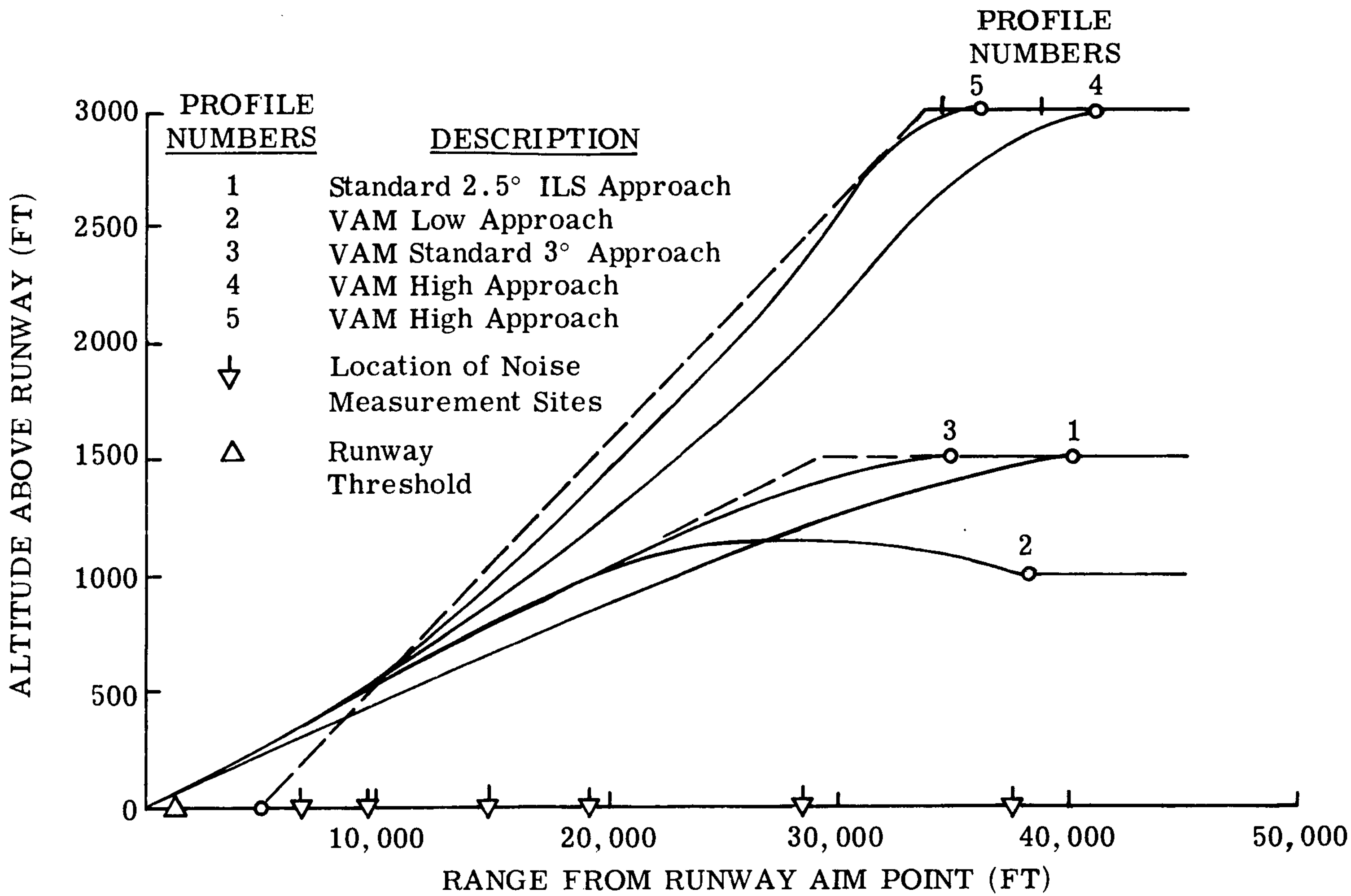

Figure 1. Flight Test Profiles

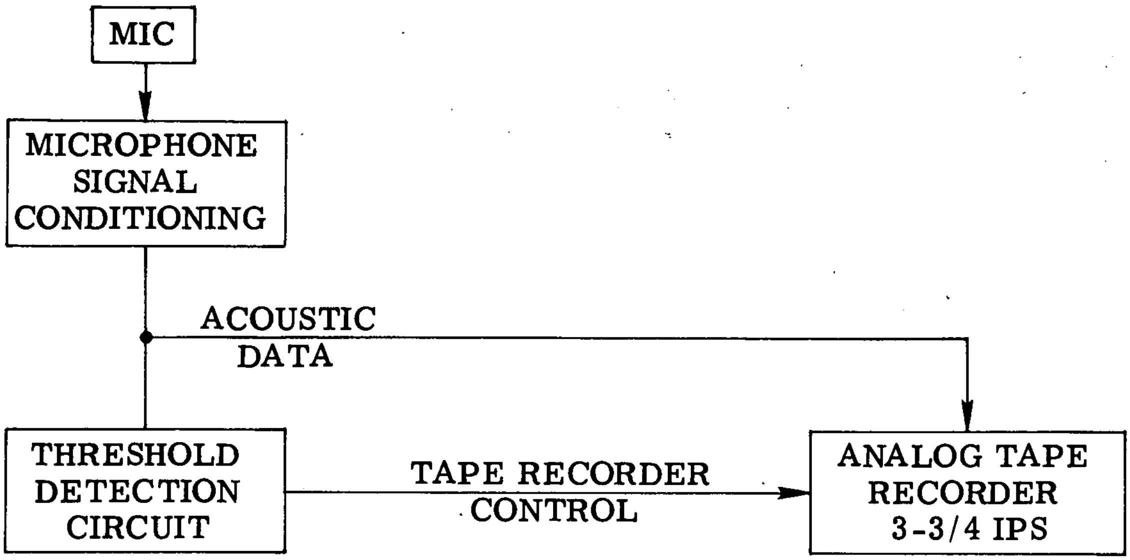

Figure 2. Acoustic Data Acquisition System

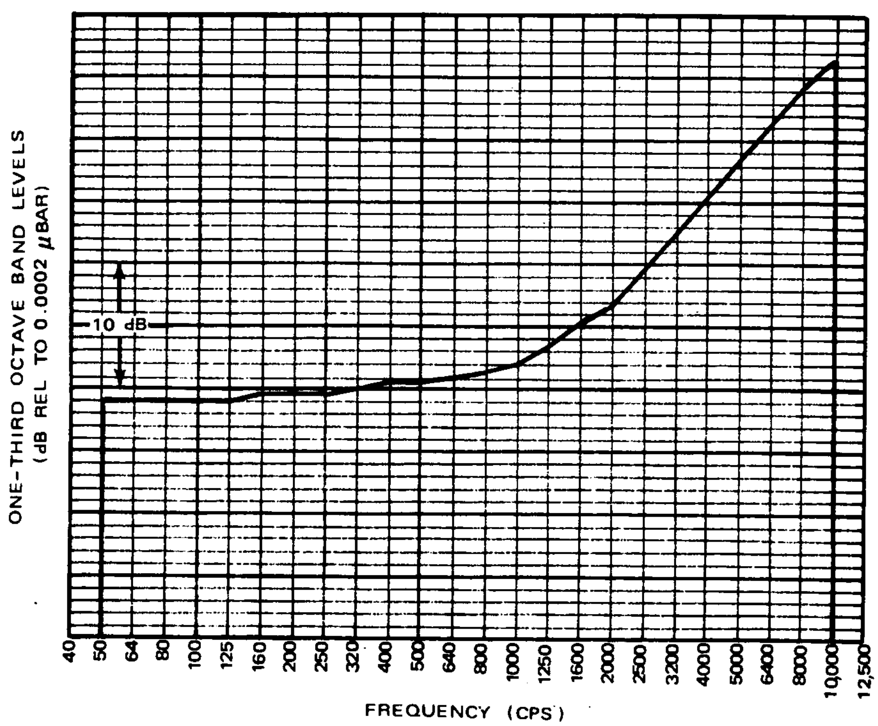

Figure 3. Typical System Response

Acoustic measurement sites 1, 2, 3, 4, 5, and 6 are located under the aircraft approach path. Table I presents the positioning of the six sites used during the exercise. All distances along the extended centerline are referenced to the runway threshold. The offset between the runway threshold and the aim point is 1250 feet.

All sites were located using a U.S. Geological Survey map. The terrain was flat farmland. Figure 4 shows the noise measurement site locations and major topographical features.

Meteorological Measurements

Table II contains the meteorological data recorded at the airport weather bureau. These data are used to correct raw EPNL to a standard acoustic day using data from Reference 1.

Aircraft Tracking

Radar tracking was provided by a Bell Aerospace radar unit. The radar provided both an on-line two-dimensional plot and analog three-dimensional data. Acoustic data processing was performed using the on-line two-dimensional radar plot. The two dimensions were slant range to touchdown and altitude.

Although three-dimensional digital tracking data is more accurate, the available two-dimensional track will introduce a maximum error in the acoustic results of less than ±0.25 EPNdB for this test. This figure is based on atmospheric absorption differences between the true slant range at the time of maximum tone-corrected perceived noise level ($PNLT_{max}$) and vertical distance at the time of $PNLT_{max}$. For this reason, one may also plot EPNL as a function of slant range from the two-dimensional track with a minimum of error.

Acoustic Data Processing

The acoustic data were processed at HRC's San Diego Operations. The processing equipment and the computer program used conform to the requirements of FAR Part 36, Reference 2. The acoustic data were adjusted for system frequency response, effect of windscreen, grazing incidence, effects of temperature and humidity, and effects of background.

Table I. Noise Measurement Site Locations

Site	Distance From Runway Threshold (ft)	Distance Perpendicular to Centerline (ft)
1	5,550	0
2	8,300	0
3	13,750	0
4	17,950	0
5	27,150	0
6	36,420	0

Table II. Stockton Weather Data - 10 March 1972

Time (LST)	Sea Level Pressure (mb)	Temperature (° F)	Relative Humidity (%)	Wind Speed (kts)	Wind Direction (deg)
0500	220	56	93	5	020
0600	224	56	93	5	020
0700	224	55	96	3	220
0800	224	56	93	6	230
0900	227	60	83	5	300
1000	234	63	77	5	330
1100	234	66	69	4	340
1200	230	67	65	4	220
1300	224	71	57	4	230
1400	213	73	51	6	300
1500	210	73	49	5	280
1600	207	74	48	12	270

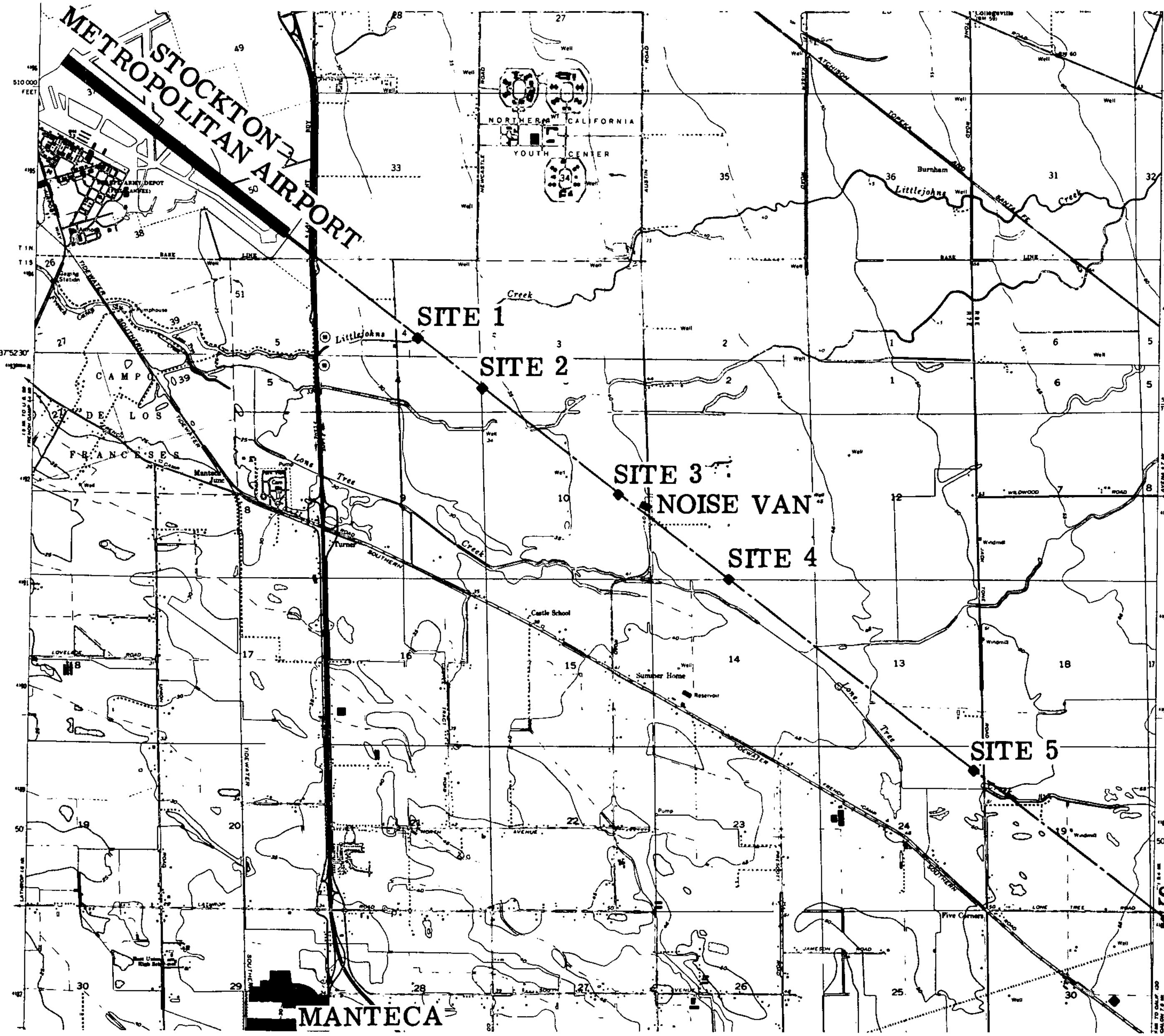

Figure 4. Measurement Site Locations

Figure 5 is a diagram of the Hydrospace Research Corporation EPNL processing technique. Analog tapes are processed using one-third octave filters to produce a digital tape of the raw one-third octave data every 0.5 seconds along with run number and calibration information. This provides the necessary memory for long duration flyovers and stores the flyover in convenient form for future work with the data. Next, the raw spectra are immediately read back into the computer and converted to true sound pressure levels utilizing the calibration information. This is then converted to raw EPNL. After entry of aircraft range, the computer reads the appropriate atmospheric corrections from digital magnetic tape and calculates corrected EPNL. This EPNL is corrected to a standard day and includes corrections for background, windscreen, grazing incidence, and gain setting. The EPNL and other support data are output to a third digital tape as an even further condensed form of the original analog tape. In addition, EPNL and support data are output to a hard copy. The above sequence is performed for every flight at each site. Additional outputs are presented on a visual display for purposes of quality control. If there are any problems, the run can be reprocessed immediately.

Results and Discussion

Acoustic measurements were made on each of the approaches. These results along with the tracking ranges at the closest point of approach (CPA) to each measurement site are given in Table III. It was noted that in some cases the test profile was not followed and the resultant profile resembled that of a different class. Of the five profiles tested, summaries of the noise data are plotted for profiles 1, 3, and 5.

Plots of effective perceived noise level versus slant range at the closest point of approach and EPNL versus distance from threshold and altitude versus distance are given in Figures 6, 7, and 8 for the three profiles. Since the aircraft often turned short over the site 6 location, these data are shown as the shaded symbols.

A summary of the noise levels as a function of distance from threshold using the VAM approaches and the standard ILS is given in Figure 9 where smooth curves have been passed through the average data points. The reduction in noise level for profiles 3 and 5 when compared with profile 1 is given in Table IV for the five sites of interest.

Table III. Tabulated Results

Profile No.	Run	Site 1 S.R.[1] (ft)	Site 1 EPNL[2] (EPNdB)	Site 2 S.R. (ft)	Site 2 EPNL (EPNdB)	Site 3 S.R. (ft)	Site 3 EPNL (EPNdB)	Site 4 S.R. (ft)	Site 4 EPNL (EPNdB)	Site 5 S.R. (ft)	Site 5 EPNL (EPNdB)	Site 6 S.R. (ft)	Site 6 EPNL (EPNdB)
1	1	310	115.9	420	113.1	645	109.8	845	104.8	1240	106.6	1630	90.4
1	2	310	118.5	425	112.4	665	110.5	840	108.1	1280	104.8	1565	100.1
3	3	365	117.4	475	111.7	670	108.4	870	96.2	--	100.4	--	99.4
4	4	390	114.4	560	106.9	945	96.3	2090	94.4	2310	91.1	--	94.9
2	5	335	118.8	450	110.4	630	113.2	720	102.9	--	100.1	--	81.6
3	6	345	116.0	500	109.2	750	99.0	960	99.2	1690	100.1	1830	102.9
4*	7	430	113.3	635	102.0	1170	95.0	1590	92.6	--	89.2	--	94.1
2	8	325	117.4	480	112.9	600	113.8	630	105.6	890	104.3	1215	101.2
4	9	365	114.2	525	111.2	925	95.7	1265	94.5	--	88.6	--	94.9
3	10	360	113.5	510	108.9	785	107.7	985	105.0	1470	96.8	1810	103.3
4	11	520	105.2	815	96.9	1440	92.2	1840	92.0	2800	89.6	2865	96.3
2	12	340	117.5	470	112.6	650	109.9	705	108.3	980	105.3	1165	105.2
4	13	450	108.3	630	103.4	1050	101.7	1410	93.9	2320	87.0	2745	96.4
3	14	360	112.8	530	105.7	840	103.5	1100	102.6	1650	100.8	1845	98.5
4	15	360	112.3	540	108.7	840	109.0	1065	95.8	1900	90.5	--	83.8
2	16	310	114.5	440	106.4	800	107.1	945	108.1	880	105.7	1280	102.3
3	17	325	116.5	530	105.2	935	95.7	1310	96.0	--	97.8	--	90.9
5	18	330	114.4	425	113.5	640	107.9	870	103.2	1520	90.8	2310	87.6
5	19	280	109.5	480	100.4	705	99.1	1465	94.1	2560	86.2	2820	84.6
5	20	320	118.2	360	112.2	670	102.0	1055	96.3	2015	88.5	2830	86.8
5	21	360	106.5	530	98.6	1095	98.2	1550	92.9	2620	88.9	2700	94.7
5	22	345	109.0	630	99.0	1175	99.1	1650	94.5	2600	93.8	2715	93.9
5	23	260	113.4	450	104.2	1020	101.2	1400	95.5	2760	89.1	2965	93.3
5	24	390	110.9	610	100.8	1115	99.2	1530	95.1	2600	83.4	2960	92.5
5	25	315	109.3	570	101.0	1150	98.6	1380	95.1	2625	87.0	2870	89.7
5	26	370	104.5	675	96.6	1275	96.0	1710	93.6	2675	85.9	2940	90.6
5	27	510	103.5	770	98.6	1400	97.1	1830	93.2	2825	89.9	2940	90.2
5	28	375	105.7	600	99.5	1120	97.5	1520	94.4	2600	87.7	2920	88.1
5	29	335	107.3	540	107.0	1095	98.4	1550	94.9	2730	87.4	2850	89.3
5	30	310	113.1	450	110.6	780	104.7	1045	100.0	1900	93.7	2190	90.2
3	31	400	112.9	505	106.2	690	109.2	905	101.3	1590	95.6	1780	87.9
4	32	330	112.8	470	112.6	725	108.6	1150	96.5	2190	84.3	2815	87.9
4	33	330	119.0	360	98.4	700	101.9	1111	99.2	1605	98.6	1820	94.4

(1) S.R. = Slant Range at Closest Point of Approach.
(2) EPNL is corrected to 77° F, 70% Relative Humidity.

*Resembed Profile 5.

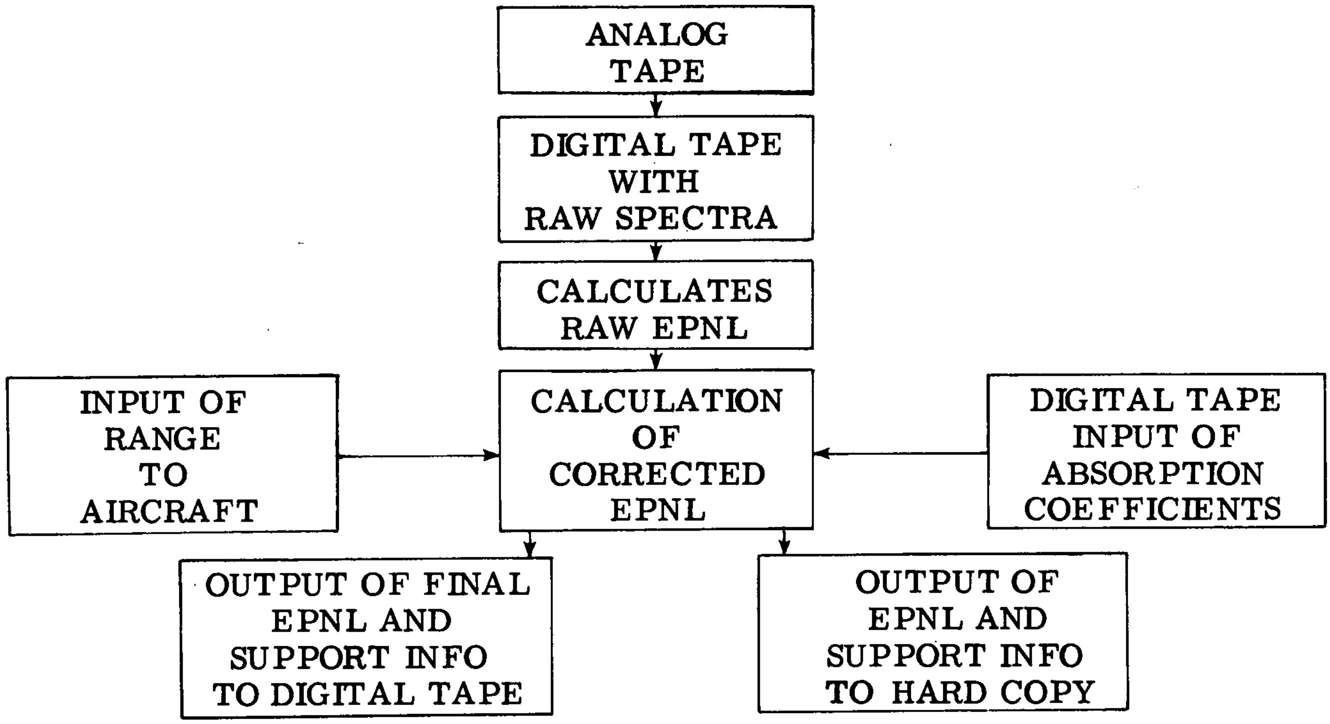

Figure 5. Processing Block Diagram

Table IV. Noise Reduction (EPNdB)

Profile No.	Site 1	Site 2	Site 3	Site 4	Site 5
3	2.5	4.0	5.0	5.5	6.0
5	8.5	9.0	11.5	13.0	17.5

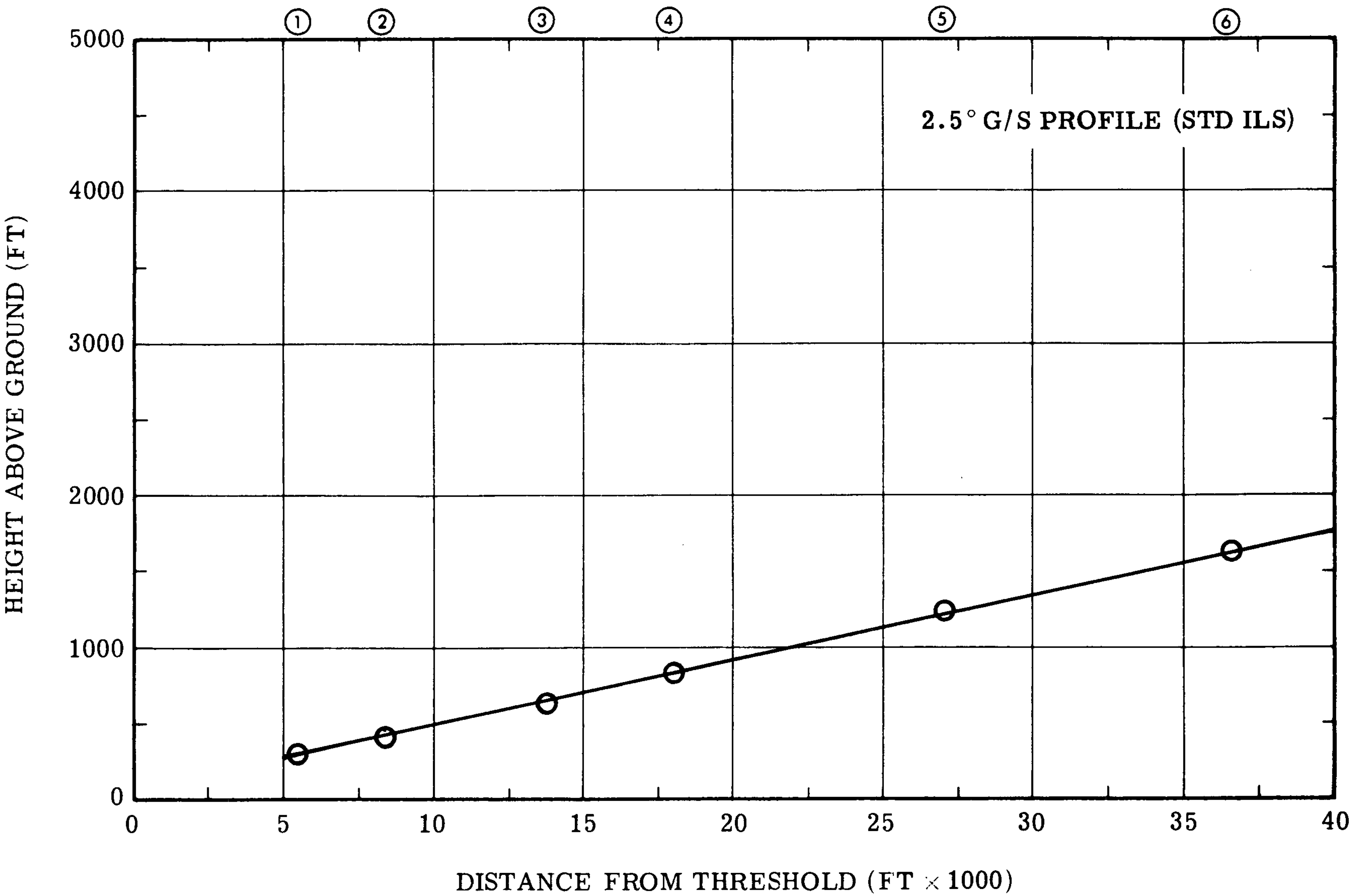

Figure 6a. Altitude Profile - Profile 1

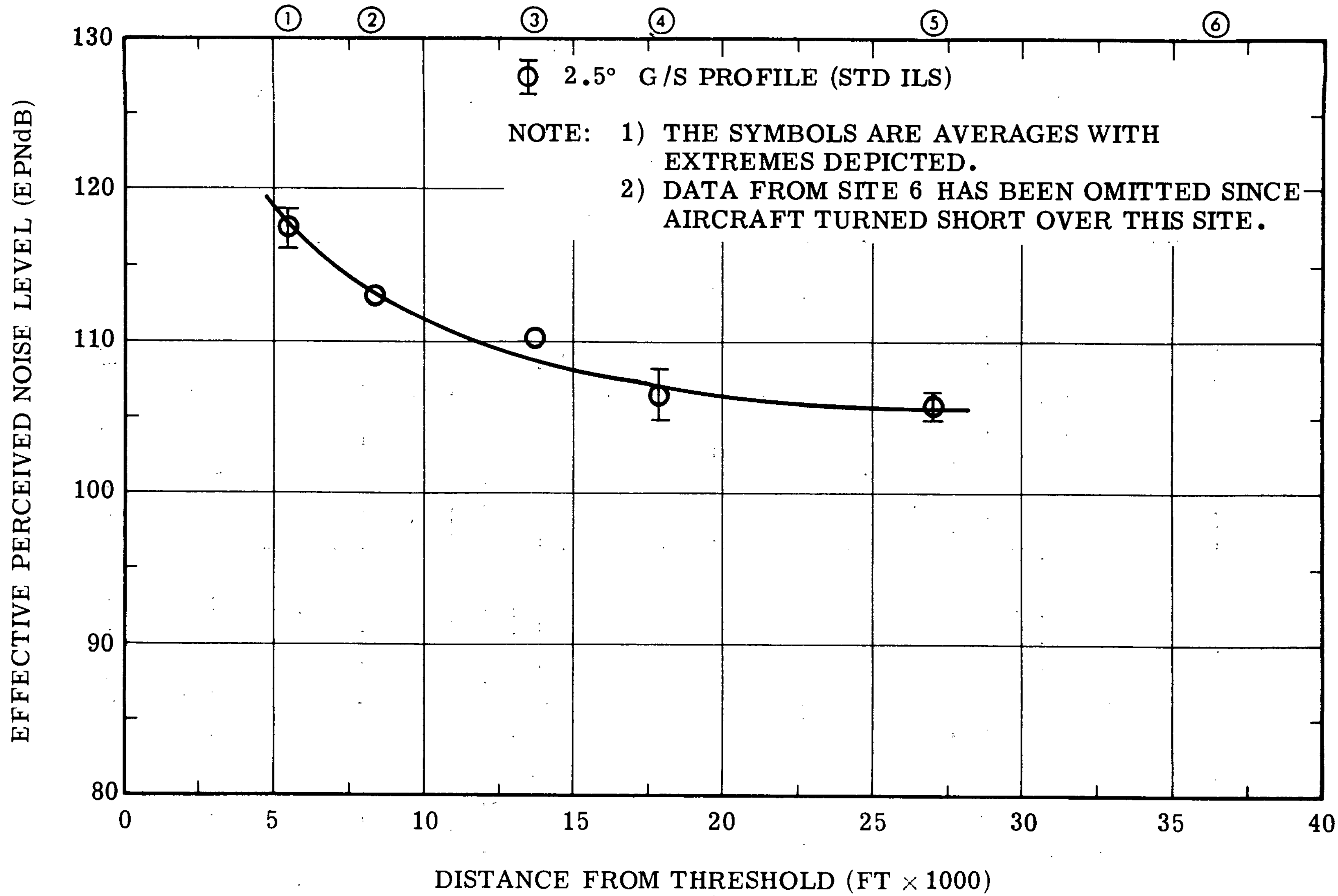

Figure 6b. Noise as a Function of Distance from Threshold - Profile 1

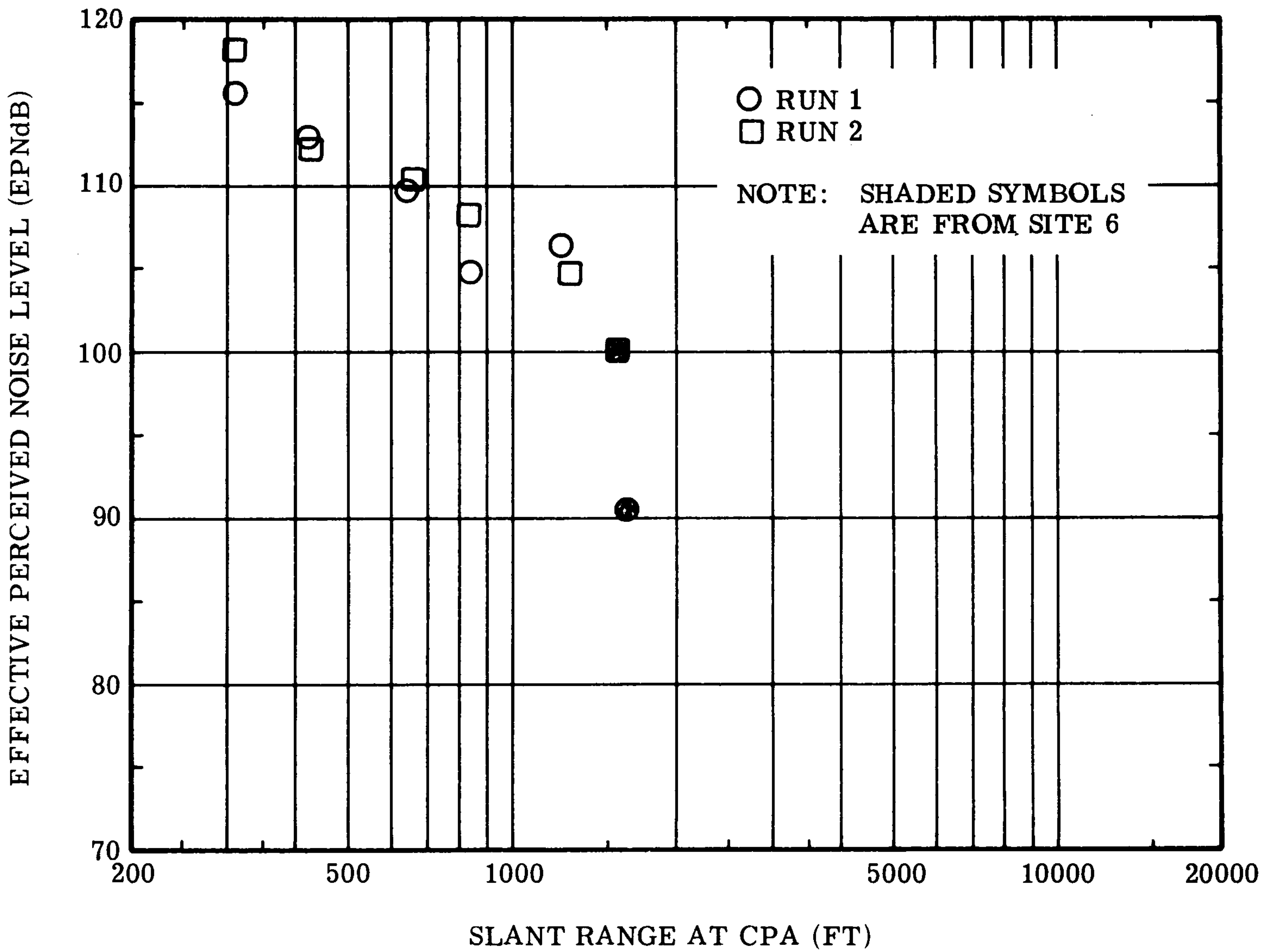

Figure 6c. Noise as a Function of Slant Range at CPA - Profile 1

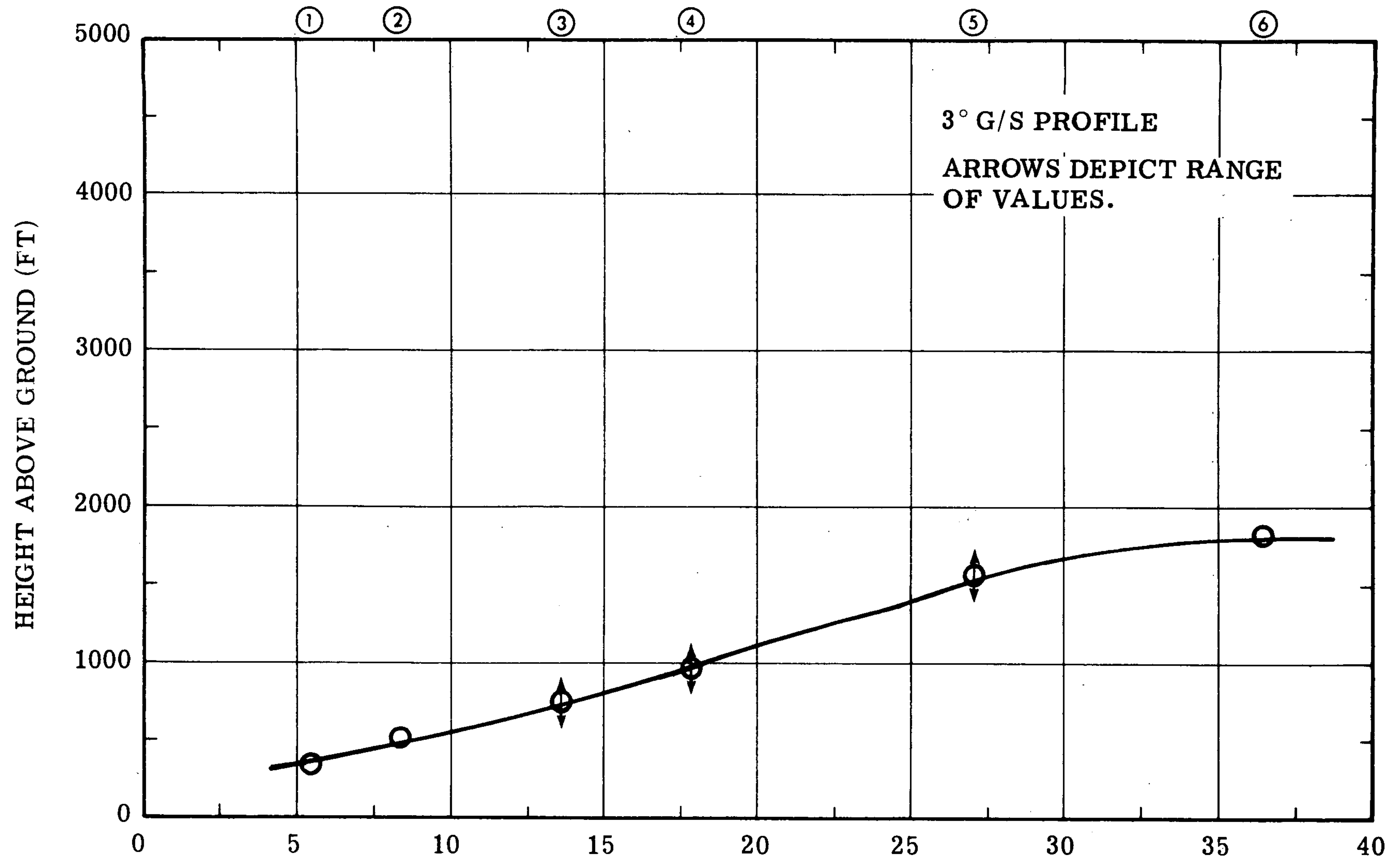

Figure 7a. Altitude Profile - Profile 3

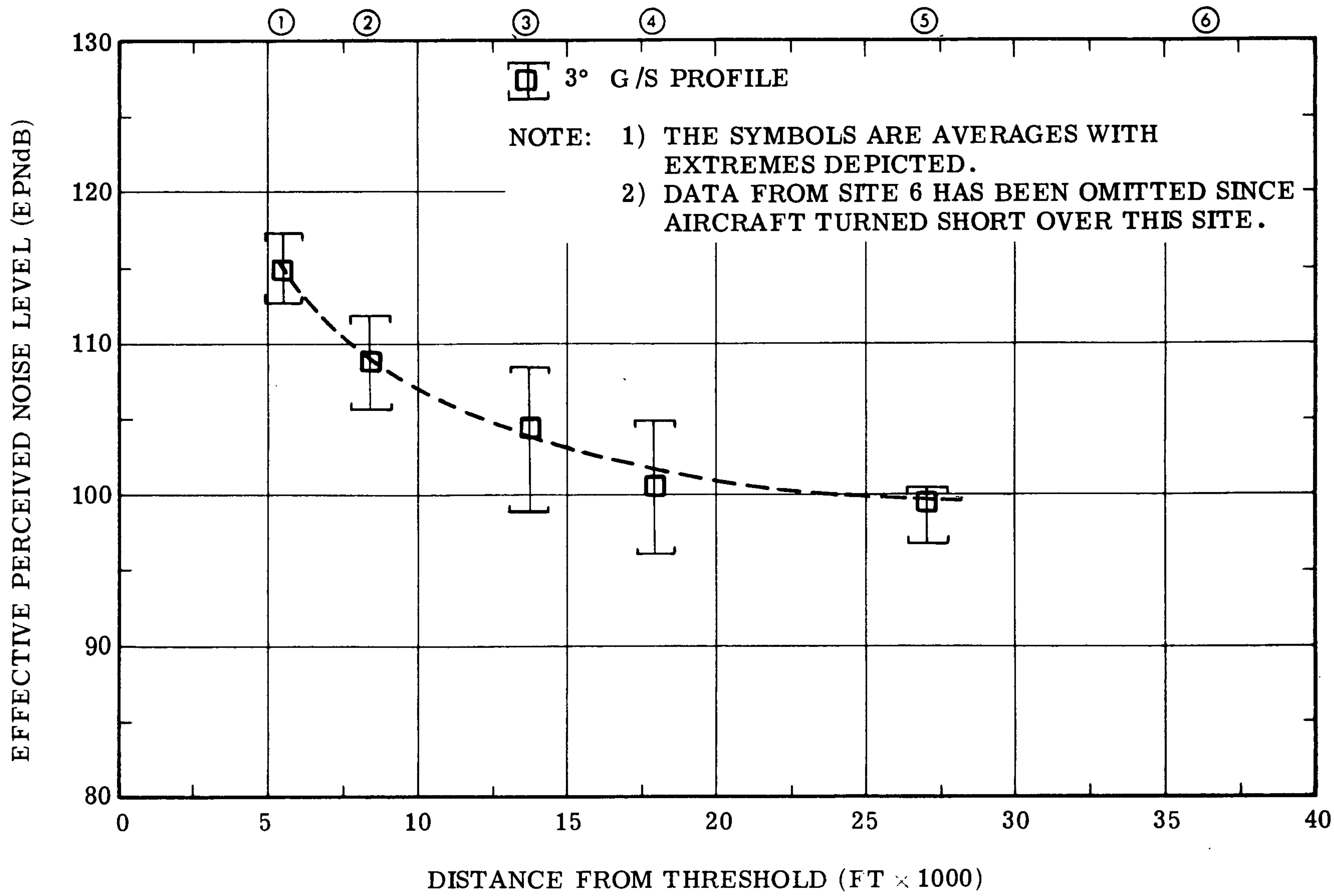

Figure 7b. Noise as a Function of Distance from Threshold - Profile 3

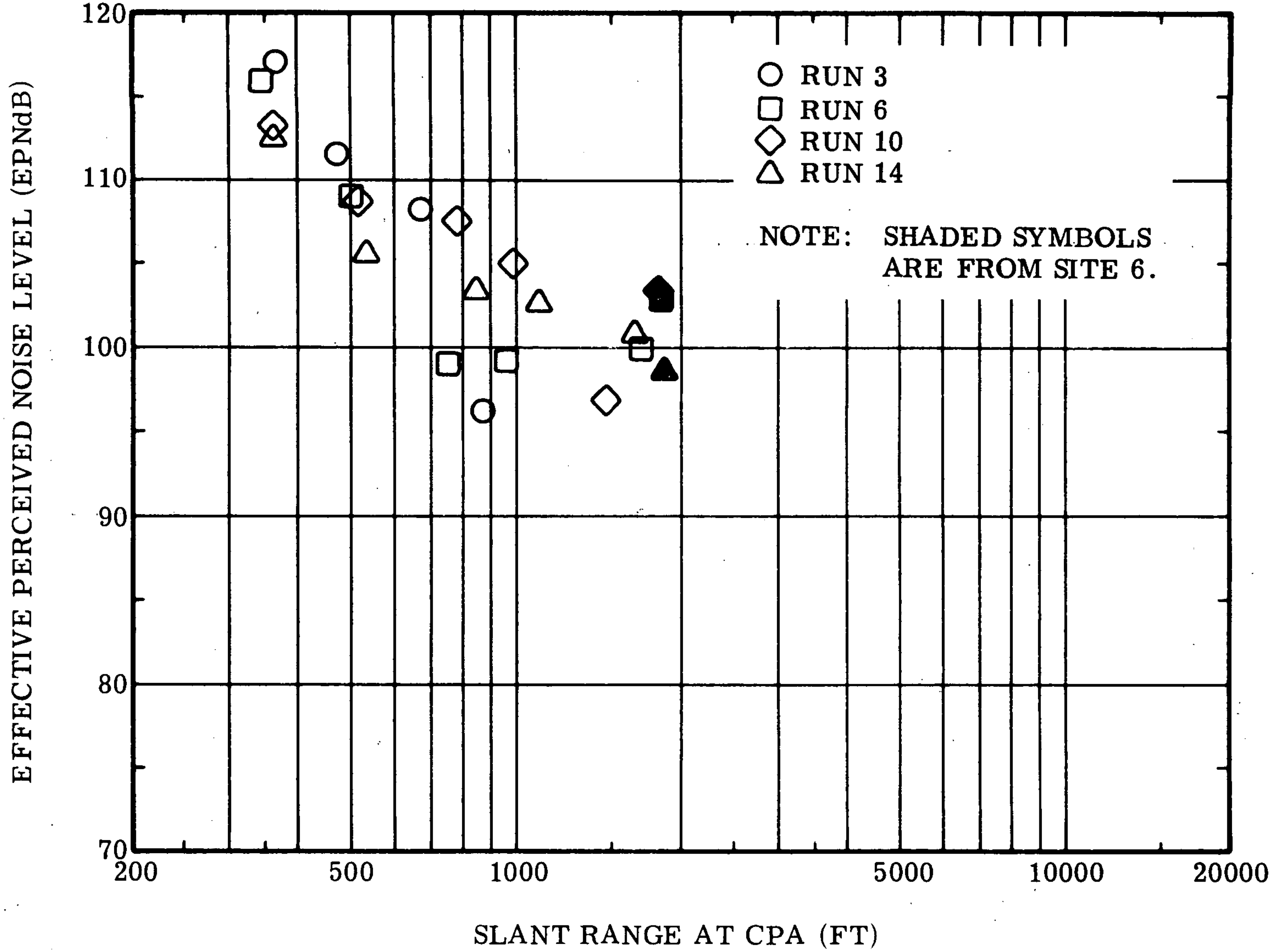

Figure 7c. Noise as a Function of Slant Range at CPA - Profile 3

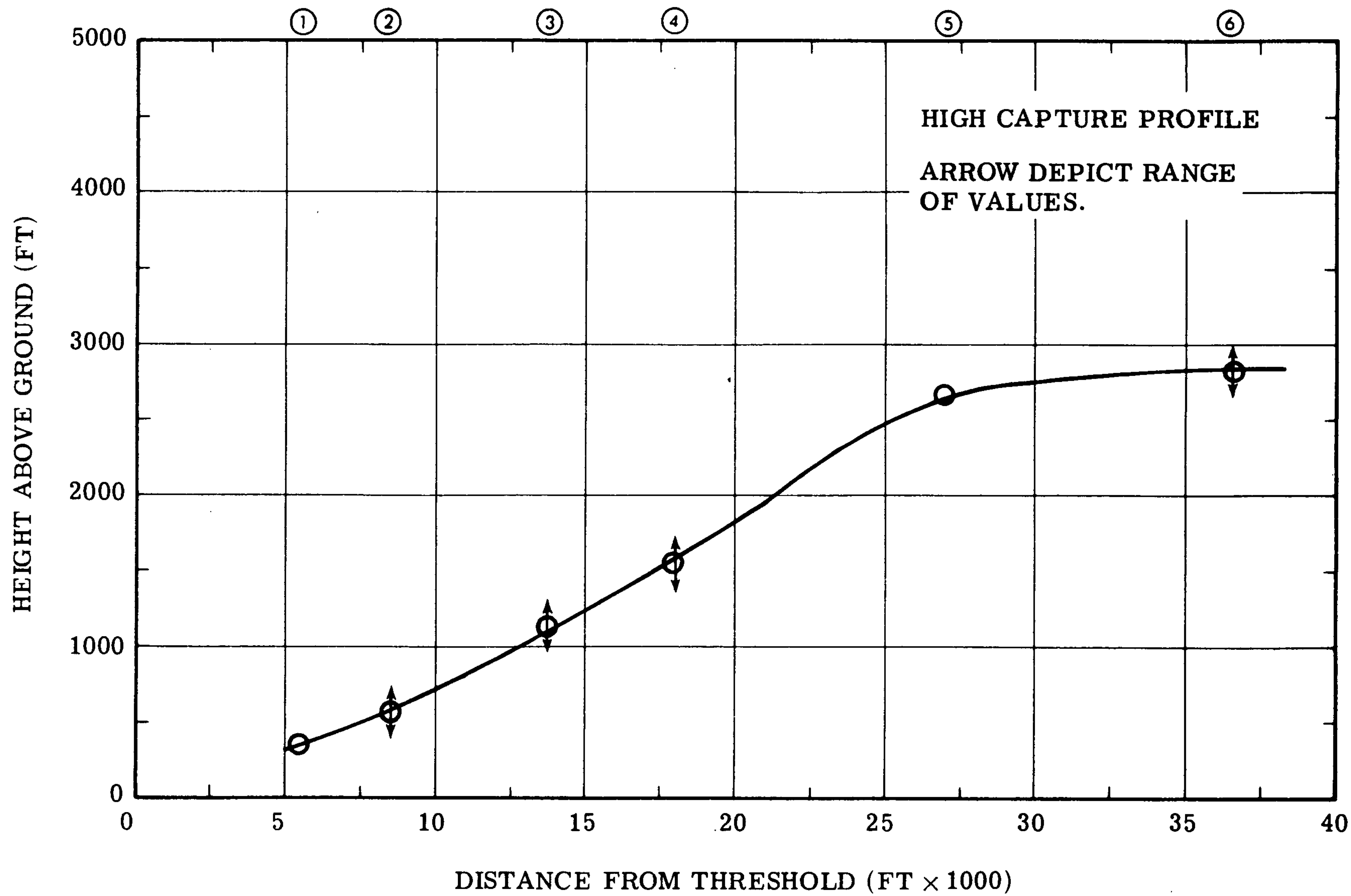

Figure 8a. Altitude Profile - Profile 5

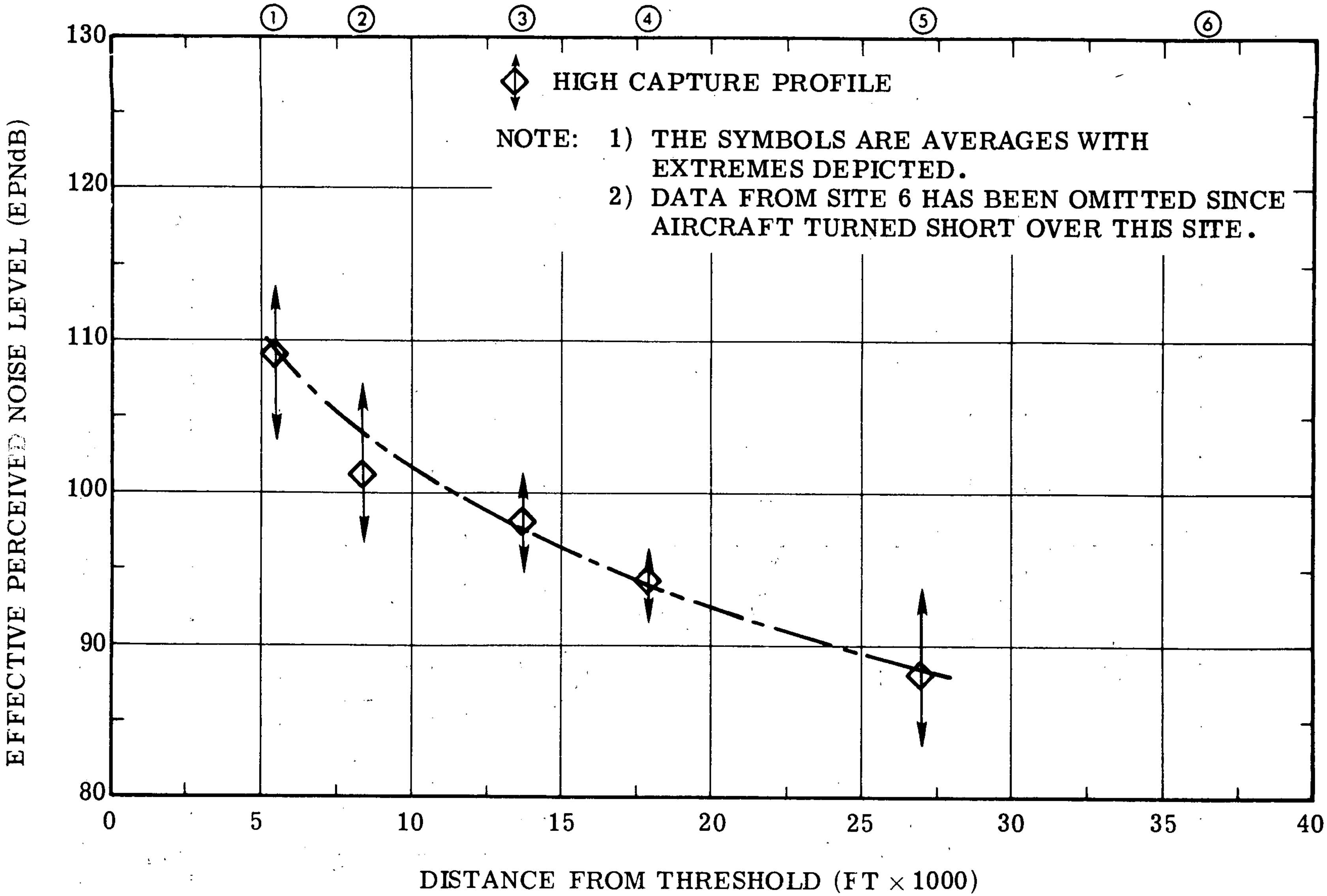

Figure 8b. Noise as a Function of Distance from Threshold - Profile 5

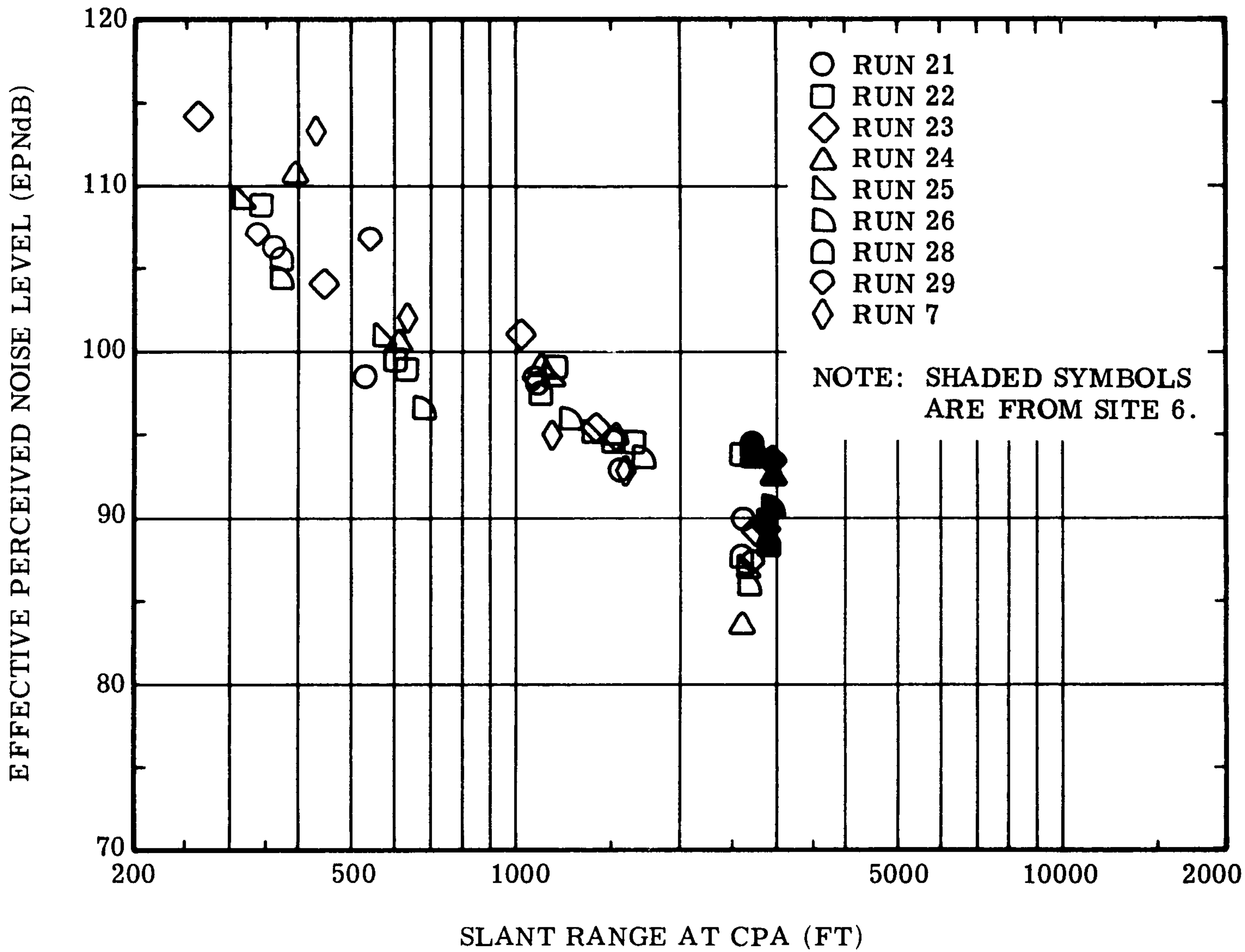

Figure 8c. Noise as a Function of Slant Range at CPA - Profile 5

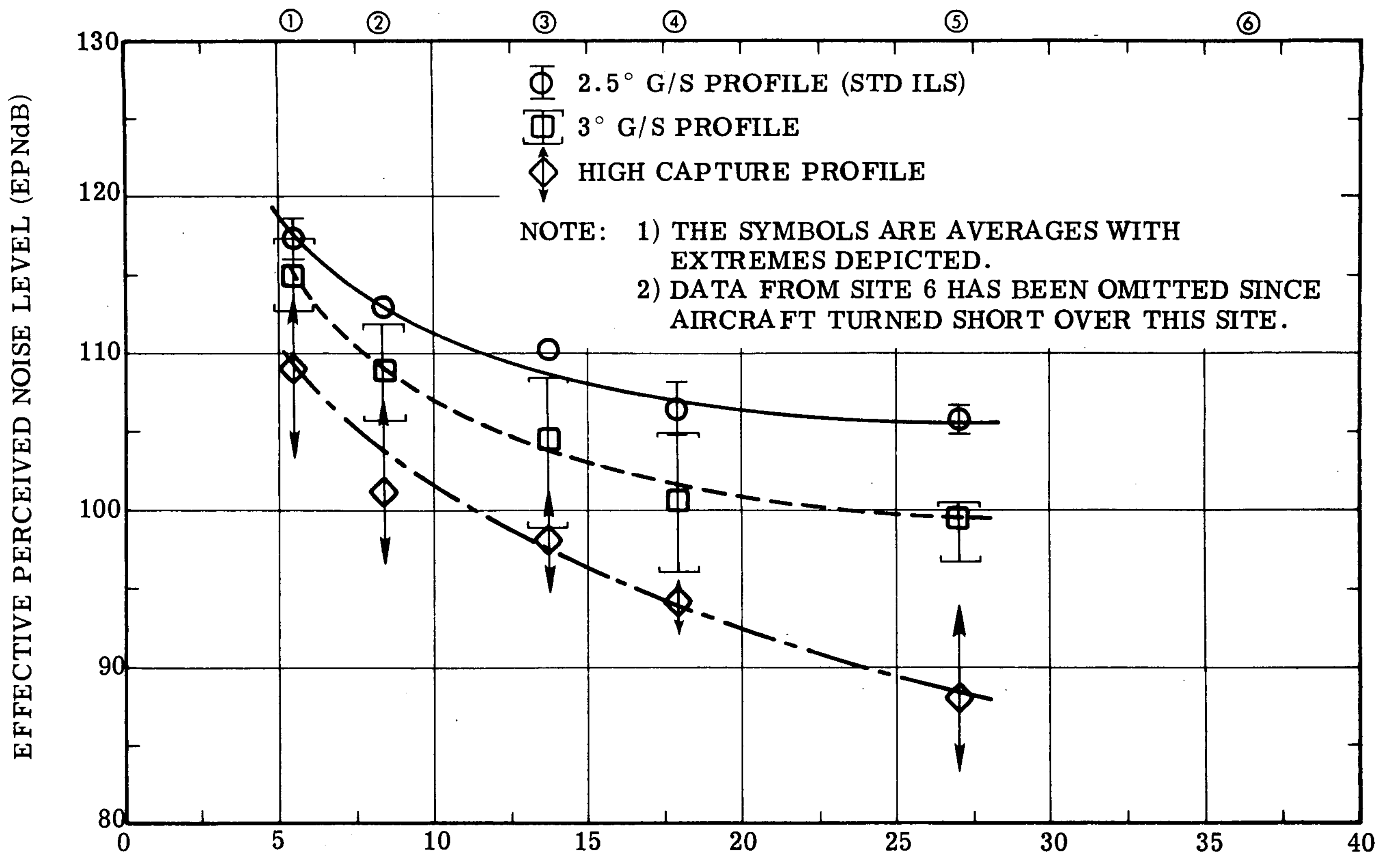

Figure 9. Summary of Noise Levels for Profiles 1, 3, and 5

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1. Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity for Use in Evaluating Aircraft Flyover Noise, Society of Automotive Engineers, Aerospace Recommended Practice Report Number 866, 31 August 1964.

2. Federal Aviation Regulations, Part 36 - Noise Standards: Aircraft Type Certification, November 1969.